

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>1 OF 15</b>

## Contents

- 1.0 Purpose/Scope**
- 2.0 Responsibilities**
- 3.0 Definitions**
- 4.0 Prerequisites**
- 5.0 Precautions**
- 6.0 Procedure**
- 7.0 Implementation and Training**
- 8.0 References**
- 9.0 Attachments**
- 10.0 Documentation**



### **1.0 Purpose/Scope**

This procedure provides a standardized method for the operation of the THM 7025 3-Axis Hall Magnetometer. It should be used in conjunction with the SBMS Subject Area Static Magnetic Fields and IH SOP IH 99110 *Static Magnetic Field Measurement Principles: Area Surveys*.

The THM 7025 provides a method for easy and accurate surveys of workplace static magnetic fields. This area survey meter should be used to determine the baseline static magnetic field levels and area SMF levels. It is designed for conducting SMF surveys to determine the need for area warning posting, estimation of personnel exposure, locate problem-SMF sources, and measuring the effectiveness of engineering controls. It should be used in conjunction with a string with paperclips to map magnetic force fields that may affect an object. The types of items that can be surveyed with this instrument include static sources such as permanent magnets, Magnetic Resonance Imaging (MRI) equipment, Nuclear Magnetic Resonance (NMR) equipment, superconducting coils, accelerator magnets, detector magnets, dc magnets in radio frequency and microwave tubes, ion pumps, electron microscopes, beam transport magnets, and electromagnetic lifting devices.

The THM 7025 can be used as a screening tool to determine the need for personal monitoring and to sketch isometric lines for control area delineation. Generally, employee exposure assessments close to exposure limits should be made with a Static magnetic field dosimeter (such as the Holiday Instrument HI-3550 Magnetic Field Monitor). However, this area survey

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>2 OF 15</b>

meter can be used to conduct baseline exposure assessments, determine the need for further dosimetry, and measure exposure in operations that are of short duration and involve limited employee movement. This information can only be used for projects that are at fixed field strengths and for static magnetic fields (DC). If the strength is changed, or experiment is modified, then resurveying is necessary or the worst exposure scenario should be assessed. If the meter reading is to be used to measure the actual employee exposure, then the entire procedure should be observed and information regarding the length of the duration in the field and a description of the procedure including number of times the procedure was performed in the area if it is a repetitive procedure must be documented.

## 2.0 Responsibilities

- 2.1 **Program Administration:** This procedure is administered through the SHSD Industrial Hygiene Group.
- 2.2 Members of the SHSD Industrial Hygiene Group are required to follow this procedure.
- 2.3 Other BNL organizations that provide BNL with field monitoring or other hazard assessment services are required to follow this SOP or an equivalent document that ensures an equal or superior method of assessment documentation and recordkeeping.
- 2.4 **Industrial Hygiene Professional:** The *Industrial Hygiene Professional* of SHSD and other BNL organizations are to be qualified by their supervision. These individuals will conduct or supervise industrial hygiene hazard assessments and personal exposure monitoring using this procedure. These *IH Professionals* are responsible for:
- Interpreting, reporting, and documenting personal exposure monitoring in accordance with the requirements of this procedure, other appropriate SOPs, and generally accepted professional standards and practices.
  - Ensuring a quality report is prepared that documents the exposure, evaluates the relevance to exposure standards, and recommends protective and corrective actions.
  - Ensuring the final report is provided in a timely manner to all appropriate parties.
  - Ensuring that the appropriate data is correctly and completely entered into the BNL IH exposure monitoring database (i.e. *Compliance Suite*®).
  - Ensuring that original records of sampling and analysis enter the SHSD *Record Custodian* filing system.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>3 OF 15</b>

2.5 **Industrial Hygiene Technician (Sampler):** The industrial hygiene technician is to be qualified by their supervision to conduct industrial hygiene personal exposure monitoring under the direction of his/her organization's *IH Professional*. The sampler is responsible for collecting personal exposure monitoring samples in accordance with the guidance of the *IH Professional* and the requirements of all SOP's pertinent to the particular monitoring requirements (i.e. Chain of custody, equipment check in/out, equipment operation, recordkeeping, etc.).

2.6 **Compliance Suite<sup>®</sup> data entry:** The management of the person conducting the sampling is responsible for entering complete and correct data into the BNL IH exposure monitoring database (i.e. *Compliance Suite*). This task may be assigned to one or more individuals who act as the data entry person for an organization, however, it remains the responsibility of the line management of the *Sampler* to ensure this task is fulfilled within 21 calendar days of the end of the sampling event.

### 3.0 **Definitions**

- 3.1 **Gauss (G)** – in the CGS system, this the unit for one flux line passing through one square centimeter.
- 3.2 **Magnetic Field** – for static magnetic fields and extremely low frequencies, this is generally used for the magnetic flux density. When referring to RF and microwaves, the term usually means magnetic field strength (H field).
- 3.3 **Magnetic field strength** –(H) vector field ( ) with units of amps per meter.
- 3.4 **Magnetic Flux Density (B) Gauss:** The number of magnetic flux lines per area that is induced by an applied magnetic field intensity H. The B results from an applied H is given by  $B = \mu H$ , where  $\mu$  is the permeability (sometimes referred to as the *absolute permeability*) of the magnetic material in which the flux is contained. Where U is zero then  $B=H$ .
- 3.5 **Magnetic Field Strength or magnetizing force (H)** - The force within the magnet that produces the flux lines.

It must be understood that flux density and magnetic field strength are related but not equal. The intrinsic characteristics of the magnetic material must be considered. Only in free space (air) are flux density and field strength considered equal.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>4 OF 15</b>

3.6 *Occupational Exposure Limit:* The maximum time weighted average (TWA) or ceiling value exposure permitted for employee exposure, based on the less of the OSHA Permissible Exposure Limits (PEL) or ACGIH Threshold Limit Value (TLV). OSHA does not have a static magnetic field standard. BNL has adopted OELs are cited in the Static Magnetic Field subject area.

3.7 *Tesla (T)-* In the SI system this is 10,000 lines per square centimeter. Unit of magnetic induction or magnetic flux density (B field) in the meter-kilogram-second system (SI) of physical units. One Tesla equals one Weber per square meter (or magnetic flux per unit area), corresponding to  $10^4$  gauss

## 4.0 Prerequisites

### 4.1 Training prior to using this meter:

- 4.1.1 Demonstration of proper operation of the instrument to the satisfaction of the employee's supervision.
- 4.1.2 Other appropriate training for the area to be entered (check with ESH coordinator or FR Representative for the facility).
- 4.1.3 Static Magnetic Field Training and review of the subject area Static Magnetic Fields.

### 4.2 Area Access:

- 4.2.1 Contact the appropriate Facility Support Representative or Technician to obtain approval to enter radiological areas.
- 4.2.2 Verify with the appropriate Facility Support Representative or Technician if a Work Permit or Radiological Permit is needed or is in effect. If so, review and sign the permit.
- 4.2.3 Use appropriate PPE for area

## 5.0 Precautions

### 5.1 Hazard Determination:

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>5 OF 15</b>

- 5.1.1 The operation of this meter does not create any chemical, physical, or radiological hazards. The meter design does not cause significant ergonomic concerns in routine use. The meter does not generate Hazardous Waste.
- 5.1.2 If individuals using the meter wear pacemakers, or other medical electronic devices, they may not be exposed to fields greater than or equal to 0.5 mT (5 Gauss). Also, individuals with ferromagnetic implants should not be exposed to levels greater than or equal to 60 mT (600 G) without clearance from the Occupational Medicine Clinic.
- 5.1.3 Protection of the meter: The THM 7025 can theoretically measure magnetic fields up to 2 T. However strong magnetic fields effect the test instrument:
  - 5.1.3.1 With the battery inside, the main unit should not be exposed to magnetic fields stronger than 0.1 T as it might be pulled away from the hands of the user.
  - 5.1.3.2 Even when the battery is removed, the main unit should not be exposed to magnetic fields stronger than 1.5 T. Permanent damage can occur to the instrument.
  - 5.1.3.3 The transformer of the power supply contains a mass of iron. The plug-in power supply should never be exposed to magnetic fields stronger than 0.1 T as permanent damage can occur to the instrument.
  - 5.1.3.4 Storage temperature of equipment: -20 C to +60 C.
  - 5.1.3.5 Operating temperature of equipment: 0 C to 40 C.

## **5.2 Personal Protective Equipment/Other Precautions:**

- 5.2.1 Check area for warning signs and instructions to the area before entering. Follow recommendations. Additional PPE: Other appropriate PPE may be needed for the area being entered. Check with your ES&H Coordinator or Facility Support Representative.
- 5.2.2 Exposure levels as low as 1 mT (10 Gauss) have been reported to cause deletion of information on magnetic memory materials, such as found on credit cards, identification badges, computer disks, and video tapes. Watches may be stopped. Use nonmagnetic objects or tools when working with or around magnetic fields above 60 mT. These objects may be drawn into the magnet and pose a flying object hazard. Metal-toed safety shoes may also be affected.

- 5.3 **Job Risk Assessment:** Consult the *Job Risk Assessment* below for the hazards and controls of this SOP.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>6 OF 15</b>

## 5.4

	1	2	3	4	5
Frequency	≤once/year	≤once/month	≤once/week	≤once/shift	>once/shift
Severity	First Aid Only	Medical Treatment	Lost Time	Partial Disability	Death or Permanent Disability
Likelihood	Very Unlikely	Unlikely	Possible	Probable	Multiple

Activity	Hazard	Control(s)	Before Additional Controls						Control(s) Added to Reduce Risk	After Additional Controls						% Risk Reduction
			Stressor	# of People A	Frequency B	Severity C	Likelihood D	Risk* AxBxCxD		Stressors	# of People A	Frequency B	Severity C	Likelihood D	Risk* AxBxCxD	
Taking measurements with direct reading meters	Health effects of Exposure to SMF fields	Observation of meter reading and maintaining appropriate distance from hazardous levels.	N	1	2	1	3	6								
	Metal object attraction	Use of non-ferrous metal tools, measurements of field strength from low to high strength, signs	N	1	2	2	2	8								
	Exposure to other hazards such as chemicals and ionizing radiation	Follow Work Control Procedures and Radiological Work Permits in the area	N	1	2	2	2	8								

## 6.0 Procedure

**Operation of the THM 7025** (picture of meter and description of controls and displays is contained in Appendix 8.1.) These instructions are only for manual use: and do not describe use with a serial interface cable and a computer. (Consult manufacturer instruction for details on remote operation.)

### 6.1 Equipment: (Illustrations in Appendix 8).

- Meter Body
- Sensor3-axis sensor (model THS7025-10) with its 1.5 meters shielded cable
- One 9 Volt Lithium battery. Life – 22 hours.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>7 OF 15</b>

- 110V or 220V plug-in power supply (model HPS7015-10). Pictured in Appendix 8.2
- Zero-field chamber (model ZFC7015-16).
- 3-meter serial interface cable with Sub-D 9 poles IBM-PC type connector (model SC7015-13).
- Non- magnetic measuring stick

## 6.2 Battery installation

- 6.2.1 Check the battery before installation with a voltmeter. The life of the battery is 22 hours.
- 6.2.2 Slide the battery door at the back of the unit.
- 6.2.3 Install the 9V battery and replace the battery door.
- 6.2.4 Plug the sensor into the connector at the top of the unit.
- 6.2.5 Turn on the THM 7025 by pressing the ON/OFF switch for at least 1 second.
- 6.2.6 Note: There is no way to check the battery during operation. When the battery is too low, the display indicates “BAT” and a few minutes later, the THM 7015 switches off by itself. Maintain a spare battery in the case.

## 6.3 ON/Off Switch

- 6.3.1 Press once for at least 1 sec: Instrument is On.
- 6.3.2 Press again: Instrument is Off.
- 6.3.3 The THM 7025 switches off automatically after ~3 minutes, if the on/off switch has not being used or if no RS 232c command is sent. To disable the automatic switch OFF, press the button <HOLD>, hold it and then press <ON/OFF>. The display shows “ON” for about 0.4s to indicate that the instrument is now ON until you turn it Off by using the <ON/OFF> button.

## 6.4 Warm-up: A warm-up is not required for this meter.

- 6.5 **Range:** The values of measurement are displayed in three ranges: 19.99 mT, 199.9 mT, 1999 mT. When the THM 7025 is switched ON, it is set on autoranging mode and it displays the measurements in the most appropriate range. This feature can be turned off and a specific range can be selected by pressing the <RANGE> button a series of times.

Press <Range>button	Range of measurement	Range indication in the display
None. Default machine status	Autoranging	
1 <sup>st</sup>	Up to 1999	0

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>8 OF 15</b>

2 <sup>nd</sup>	Up to 199.9	0.0
3 <sup>rd</sup>	Up to 19.99	0.00
4 <sup>th</sup>	Autoranging	Auto

## 6.6 Reading Hold

- 6.6.1 As long as the button <HOLD> is pressed down, the display of the measured value is held. The sign ▲ comes in the display. By releasing <HOLD> the THM 7025 continues its measurement and gives new valued.
- 6.6.2 The normal operation of the Hold function is.
  - 6.6.2.1 When meter is powered: Meter operates in the running mode
  - 6.6.2.2 Depress <HOLD>: Meter displayed value as long is button depressed
  - 6.6.2.3 Release<HOLD>: Meter returns to the running mode

## 6.7 Calibration:

- 6.7.1 Check the display to determine if the meter is reading zero prior to each survey. The offsets of the Hall sensors are calibrated at the factory. This is called System Offset.
- 6.7.2 If the display does not read zero, place the probe in the zero field chamber in an area without a magnetic field. DO NOT REZERO WHEN SENSOR IS IN A MAGNETIC FIELD otherwise the measurements will be dependent on the sensor orientation.
- 6.7.3 Press and hold the <ZERO> button, the press the <HOLD> button. The new offset is measured and memorized. The machine retains this measurement even after switching off the THM 7025. Record re-zeroing on data sheet.
- 6.7.4 To restore the factory System Offset, press and hold the <ZERO> and press<ON/OFF>. This action resets the default parameters.

## 6.8 Operation:

- 6.8.1 **Operator Position:** Preferably the operator should be further from the magnetic source than the probe. Use a non-metallic extender if necessary. Note the distance from the source, and location of the measurements.
- 6.8.2 Use the default auto range or select the desired display range (see 6.5).
- 6.8.3 Point the meter at the source. If you do not know the strength of the magnet, approach source slowly from a distance so that you are not beyond the

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>9 OF 15</b>

capabilities of the meter, and there is no potential for the meter being pulled out of your hand.

- 6.8.4 Observe and record the readings shown on the display in a running mode or hold mode.

### 6.9 Use of Bz Button (B on Z axis)

- 6.9.1 For survey purposes, this feature is not used, the default **3 axis feature** is used. Pressing the Bz button toggles between the 3 and single axis measurements.
- 6.9.2 To distinguish between the modes, the sign “+” or “-” will appear with the **magnetic field value in single axis mode**. Otherwise no sign is displayed.

### 6.10 Recording readings:

Plan and conduct hazard assessments and exposure monitoring using the procedure outlined in *IH 60500 Reporting Personnel Exposure Monitoring Results* for:

- Exposure Assessment Sampling Strategy,
- Initial Notification of Employee Monitoring Results, and
- Preparation of a formal report on the exposure monitoring or hazard assessment.

- 6.10.1 See the Subject Area *Static Magnetic Fields* for the most recent version **SMF Use form**.
- 6.10.2 Return meter and original sampling form to the SHSD IH Laboratory daily or at the end of each project as agreed to by the IH Laboratory Technician.
- 6.10.3 Send a copy of any hazard evaluation report written on the survey to the IH Laboratory.
- 6.10.4 If this survey determines that employees are potentially exposed at or above the 0.5 (5 gauss level) for pacemaker users, or above any of the other BNL exposure levels, then identify the employees on the Static Magnetic Field form Part C, Employee Exposure Record, and forward a copy to the IH laboratory and the Occupational Medicine Clinic.

## 7.0 Implementation and Training

Prior to using this procedure, the user:

- 7.1 Demonstrates proper operation of this instrument to the satisfaction of line supervision or SHSD IH Program Administrator.
- 7.2 Completes other appropriate training for the area to be entered (check with ESH coordinator or FS representative for the facility).
- 7.3 Completes OT&Q Training and a medical surveillance required for any PPE used on

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>10 OF 15</b>

the job or for other hazards encountered in the work area.

- 7.4 Completes qualification on this procedure on at least a 3 year basis, providing the professional uses the equipment several times per year.
- 7.5 Personnel are to document their training using the Qualification Criteria listed in *IH51800 Industrial Hygiene Service Delivery Basic Qualification Requirements*.

## 8.0 References

- 8.1 THM 7025 User's Manual.
- 8.2 BNL SBMS Subject Area – Static Magnetic Fields.

## 9.0 Attachments

- 9.1 Photo of meter and parts
- 9.2 Short Operating Instructions
- 9.3 Theory of Operation

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:  <b>THM 7025 3-Axis Hall Magnetometer</b>	INSTRUMENT OPERATION:  	DATE <b>03/29/05</b>
		PAGE <b>11 OF 15</b>

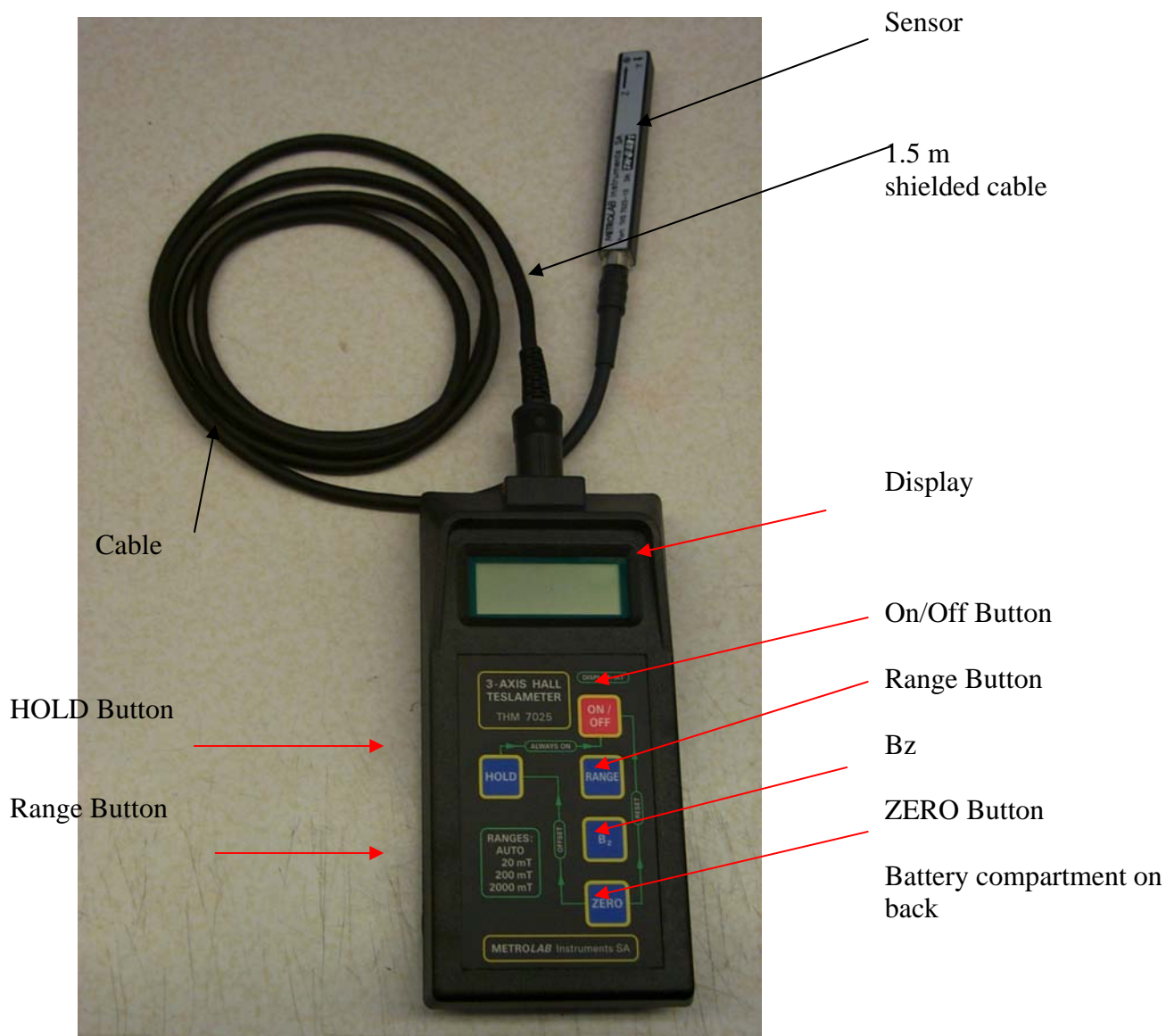
## 10.0 Documentation

Document Review Tracking Sheet		
<b>PREPARED BY:</b> <i>(Signature and date on file)</i> <b>N. Bernholc</b> Author <b>Date 07/02/01</b>	<b>REVIEWED BY:</b> <i>(Signature and date on file)</i> <b>J. Peters</b> SHSD IH Group <b>Date 07/02/01</b>	<b>APPROVED BY:</b> <i>(Signature and date on file)</i> <b>R. Selvey</b> SHSD IH Group Leader <b>Date 07/05/01</b>
<b>Filing Code:</b>  <b>IH51SR.01</b>	<b>DQAR</b> Date	<b>Effective Date:</b>  <b>07/06/01</b>

Periodic Review Record		
Date of Review	Reviewer Signature and Date	Comments Attached
03/29/05	<i>(Signature and date on file)</i> R. Selvey 03/29/05	Revised to include Section 7 Implementation and Training. Text added to Section 2, 4, 5, 6, and 7. JRA added to Section 5.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>12 OF 15</b>

## Attachment 9.1 Photo of Meter



<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>13 OF 15</b>

## Attachment 9.2

### Short List of Operating Instructions/Trouble shooting messages

Step	User Action	Digital Display
1	<b>Battery Check</b>	Battery must be checked before installation
2	<b>Calibration</b>	If the battery is low the display reads <i>bat</i>
3	<b>Operation</b>	<ul style="list-style-type: none"> <li>Power button <b>ON</b></li> <li>Connect probe</li> <li>In static magnetic field free area (0.1 mT) place probe in zero field chamber</li> <li>Press button &lt;ZERO&gt;, hold it and press button &lt;HOLD&gt;.</li> </ul>
4	<b>Operator Position</b>	Point probe at source
		Reading digital displayed
		Stand behind the meter. It is acceptable to extend the probe towards the source. Note: the body of the instrument cannot exceed <b>0.1 Tesla (100 mT)</b> .

ACTION/SCREEN DISPLAY	DESIRED ACTION	BUTTON SEQUENCE	RESULT
Display reads "Er.n" where 'N' is the error number (see list in section)	Clear error	Press <ZERO> once	Clears the error
Error Number= " 1 "			Return to factory
Error Number= " 2 "	Clear the error	Press <ZERO> once	Clears the error
Error Number= " 3 " (Occurs when residual background field is too high to be nulled)	Clear the error	Press <ZERO> once	Clears the error
Machine does read zero in non magnetic field, or when the internal memory is saturated	Reset system offset	Place probe in zero field chamber Press <ZERO>, hold it, press <HOLD>	Zero is reset. (User's Offset established)
Restore factory defined System Offset		Press <ZERO>, hold it, press <ON/OFF>	Factory System Offset is restored.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT: <b>THM 7025 3-Axis Hall Magnetometer</b>	INSTRUMENT OPERATION: <b>THM 7025 3-Axis Hall Magnetometer</b>	DATE <b>03/29/05</b>
		PAGE <b>14 OF 15</b>

## Attachment 9.3 Theory of Operation

The METROLAB 3-axis Hall Teslameter “THM 7025” is an instrument using Hall elements to measure magnetic fields. The main feature of the THM 7025 is the simultaneous measurement of the 3 axis, X, Y, Z, which are set at 90 degree angle, allowing a direct measurement of the magnetic field intensity, without a particular orientation of the sensor (isotropic).

In the 19<sup>th</sup> century, Edwin Hall placed a gold film in a magnetic field, passed a current through the film and measured the voltage across the foil. He found that there is a proportional relationship between the voltage detected and the magnetic flux density as well as the incident angle of the flux lines. The polarity of the voltage is dependent upon the direction of the flux lines.

The THM 7025 is a modern hall effect device, commonly called a Hall Generator, comprised of three Gallium Arsenide or Indium Arsenide films at right angles to detect the flux lines in three dimensional space. The films are located in the probe and are supported on ceramic substrates for physical and thermal stability as well as locations for wiring nodes. The readout is displayed in mT and can detect both direct current (DC) and alternating current (AC) fields.

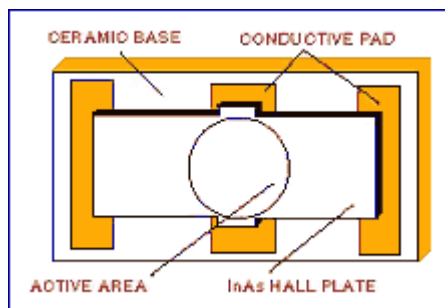
All the functions of the THM 7-25 (controls and measurements) can be accessible to a computer via a RS 232c serial interface.

The THM 7025 calculates and displays the modulus of the magnetic field as per the equation

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

Hall discovered that the voltage, now called the *Hall voltage*,  $V_h$ , is directly proportional to the number of flux lines passing through the foil, the angle at which they pass through it, and the amount of current used. He also found that the polarity of the voltage reverses when the direction of the flux travel reverses.

A modern Hall effect device (see Photo 1), commonly called a *Hall generator*, consists of a thin square or rectangular plate or film of GaAs or InAs to which four electrical contacts are made (see Figure 3).



A "bulk" Hall generator is constructed by soldering a thin slice of a III-V compound such as InAs to conductors on a ceramic substrate. Thin film devices are made by depositing the vaporized compound directly on the ceramic circuit plate.

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division  <b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure		NUMBER <b>IH 99370</b>
		REVISION <b>FINAL rev1</b>
SUBJECT:	INSTRUMENT OPERATION:	DATE <b>03/29/05</b>
<b>THM 7025 3-Axis Hall Magnetometer</b>		PAGE <b>15 OF 15</b>

The plate or film is often affixed to a ceramic substrate that provides mechanical support, thermal stability, and wiring nodes. Other devices are wire bonded to a nonmagnetic lead frame and encapsulated in a dielectric material.

The output of a Hall device is greatest when the flux lines are perpendicular to the surface of the material. When the angle is held constant, and a constant current is provided through the material, the Hall voltage is directly proportional to flux density. Conversely, holding the flux density and current constant allows the device to respond to the angle of the flux lines.

C= 3.7 mm     side of the probe is 12mm x 12 mm

The three sensor probe are located inside a 3 mm diameter sphere centered on the corner of a 3.7 mm side cube.

